Valuation of Supply Chain Flow Risks by Indexing

Paulsson, Ulf

Published in:
Papers from the 17th NOFOMA conference held in Copenhagen, Denmark, 2005

2005

Work-in-progress paper. NOFOMA 2005 conference. Copenhagen 9 – 10 June 2005.

Valuation of supply chain flow risks by indexing

Ulf Paulsson*

*) Assistant professor. PhD-student. Lund University. School of Economics and Management. Dept. of Business Administration. P.O. Box 7080. SE-221 07 Lund. Sweden. E-mail: ulf.paulsson@fek.lu.se. Tel/Fax: +46 46 307761. Mobil: +46 0706 73 13 22.

ABSTRACT

The paper is based on a general conceptual supply chain flow risk model developed in an earlier paper, a literature review and case studies. The paper has the title "Developing a supply chain risk model" and is reported as a final paper at the NOFOMA 2005 conference. The literature review has been focusing articles and reports/books on supply chain management. Some of its findings have earlier been reported in a book chapter in Brindley (2004). There is one main case-study, presented here as case Beta and two minor cases (Alfa and Gamma). The author spent five weeks during the autumn of 2004 on the floor in two of the factories of Beta. That resulted in three internal reports to Beta and a lot of experience and ideas about supply chain flow related risks including the valuation of risks through indexing. Earlier drafts of this paper have on some occasions been tested on risk managers of Beta and developed further based on their feedback. The three cases illustrate the use of the valuation model.

Finally is concluded that using indexes can be a way of quickly and with limited resources getting a broad grip of the total risks in the supply chain – not least in new risk situations. The alternative is often not to have any figure at all for the supply chain risks. But we have to be careful because indexes create a new risk – the risk that we believe too much in them.

Key Words: Case study, Disturbances, Model, Risk index, Indexing, Supply chain risk, Supply chain risk management, Valuation, Vulnerability.

1. Introduction

1.1. Background

A number of *trends* like concentration of production, outsourcing, single sourcing, globalisation, and leanness have affected the supply chain flow (Christopher & Towill, 2000; Mason-Jones, Naylor & Towill, 2000). These trends (and others as well) tend to *make the supply chain flow more vulnerable*. The existence of a new risk situation in supply chains is now realized by more and more researchers and practitioners (Christopher & Lee, 2001; Juettner, Peck & Christopher, 2002; Kajüter, 2003) and the interest in supply chain risk management issues have increased considerably.

The individual company in the chain has to pay those risk issues increased attention. To be able to *manage* the supply chain flow risks the individual company needs at least:

- A general conceptual model with the help of which risks can be structured and described;
- A way of valuating those risks;
- Knowledge about risk-handling methods;
- Knowledge about links (connections) between different risk-handling methods and different risks.

In an earlier paper (Paulsson 2005) a general conceptual supply chain flow risk model has been developed. In the present paper a way to *valuate* those risks through indexing will be presented. In two articles/papers to come the issues of risk-handling methods respectively links between different risk-handling methods and different risks will be treated.

When we discuss risks we could either do it from a static perspective or from a dynamic perspective. In this paper a *static* perspective has been chosen i.e. the risks in the supply chain are studied for a special situation at a certain point of time.

1.2. Objective

The *objective* of this paper is to, seen from the perspective of a single company in the chain and based on an earlier developed general conceptual model, develop a simple model for a rough *valuation*, based on indexing, of the supply chain flow risks in a *static* situation.

1.3. Method

The paper is based on a general conceptual supply chain flow risk model developed in an earlier paper, a literature review and case studies. The paper has the title "Developing a supply chain risk model" and is reported as a final paper at the NOFOMA 2005 conference. The literature review has been focusing articles and reports/books on supply chain management. Some of its findings have earlier been reported in a book chapter in Brindley (2004). There is one main case-study, presented here as case Beta and two minor cases (Alfa and Gamma). The author spent during the autumn of 2004 five weeks on the floor in two of the factories of Beta. That resulted in three internal reports to Beta and a lot of experience and ideas about supply chain flow related risks including the valuation of risks through indexing. Earlier drafts of this paper were on some occasions tested on risk managers of Beta and developed further based on their feedback. The three cases illustrate the use of the valuation model.

1.4. Risk valuation principles

1.4.1. Risk – a complex concept

Risk is defined by The Royal Society “as the probability that a particular adverse event occurs during a stated period of time, or results from a particular challenge” (Risk: Analysis, Perception and Management, 1992, p.2).

Risk is *a complex concept* including a number of "questions". In for instance a study by Mullai & Paulsson (2002, page 15) of oil spill incidents risk included the following questions: When did it happen? Where did it happen? What was the initial event? Which were the contributing factors? What was the negative event? Which were the negative consequences? What was the negative impact? and What is the probability that it will happen?

Risk is always seen in relation to something. In this paper risk is related to the physical flow in the supply chain and what could cause disturbances in that flow. In Paulsson (2005, page 11) *supply chain flow risk* was defined as: *"A change in the supply chain flow, caused by a change in the environment of this flow, with negative value impact on the focal company and/or its supply chain, and the probability that this will happen"*.

Risk value is what you get if you multiply the negative impact of a certain risk with the probability of that risk to happen.

1.4.2. Real risk values

To be able to express a risk value as the product of *a real negative impact* value multiplied with *a real probability* is of course desirable. Sometimes the information is easily available, sometimes resources has to be spent on finding and calculating it, but in most situations the information is simply not there. The more frequent a risk is the more likely it will be that we could get a fair risk probability. The narrower the perspective is the more likely it will be that we could find or calculate a real impact value. But for most risks, especially if it is an infrequent and broad risk, it is simply not possible to get a fair real risk value. We will have to do without it.

In this paper focus is on supply chain risks for different parts of the supply chain but also for the total supply chain. Such risks are broad and often infrequent and could hardly be given a real risk value. But there exists nevertheless in the supply chain some kind of knowledge about the size of different supply chain risk values and this knowledge can be used to set indexes for the risks. If we add calculation rules indexes of higher order can also be calculated.

1.4.3. Risk indexes

When using the method of indexing we have to decide what to index (which indexes should we use and for what?), what should the individual range of each index be and what are the calculation rules for the creation of indexes of higher order (like a total supply chain risk index). Since we are using an earlier developed model as base it will be that model that guides us when answering those questions.

2. Risk index valuation model

Modelling is carried out in three steps: First the earlier developed conceptual general model is adapted to the special situation of valuation. Then indexes are put on the different individual

risks presented in the general model and the range of each index is decided. And finally calculation rules are added.

2.1. Adapting the general supply chain risk model

The general conceptual supply chain flow risk model developed in Paulsson (2005) had the following look:

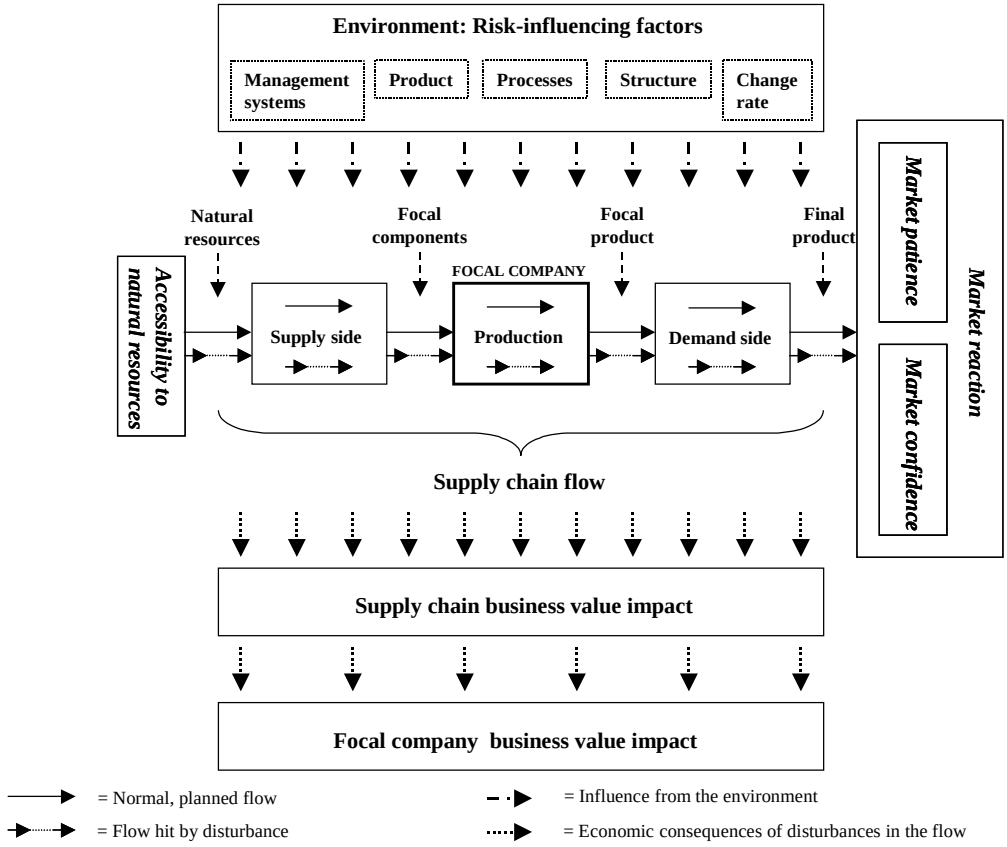

Figure 2.1 The general conceptual supply chain flow risk model (Paulsson 2005)

In the literature there are sometimes references to the supply chain as if it was a natural unit with a specific size and structure and lived a life of its own. This is as I see it not the case. The supply chain is created/specified through the choice of a focal company and a focal product. The supply chain is thus *perspective dependant*. If we look at the supply chain from the perspective of one company in a link we have one supply chain and if we i.e. choose the perspective of one the suppliers to that company then we will have a different supply chain. The only situation where the supply chain is the same regardless of which link in the supply chain you choose to focus is when there is only one company in each link of the supply chain. Such one-company-in-each-link-supply-chains might exist but are probably then very marginal. From now on I will regard the supply chain as being perspective dependant i.e. a result of the choice of a focal company (and a focal product). If this choice is changed we will get a new supply chain.

When looking at the environment we are in this paper simply only interested in *changes in general* in the environment and need in not to be more specific than that. When looking at the valuation of supply chain flow risks we will here only consider the negative impact on

business value. Risk is thus related to the negative economic effects a disturbance in the supply chain has on the business value of the focal company and/or the supply chain of which it is a part.

2.2. Risk indexes and their ranges

In Paulsson (2005) three different types of disturbances were identified. Each of these will be presented below and their impact on business value discussed. Beside the three disturbance types "disturbance multiplication" and "market reaction" will also be treated.

2.2.1. The three disturbance types

One type of disturbance is *within part* disturbances i.e. disturbances that are "created" within one single part (supply side, production or demand side) in the supply chain and are also handled within that same part. Those disturbances normally only lead to increased costs within the supply chain part in question. The indexes are marked with S for supply side, P for production and D for distribution. The indexes are indicating the size of the costs (BVI) within the part in question for handling the disturbance.

Another disturbance type is *out from part* disturbances i.e. disturbances that begin within one supply chain part but cannot be handled within that part and are therefore passed on to next supply chain part. The indexes are marked with SP for disturbances from supply side to production, PD for disturbances from production to demand side, and DM for disturbances from the demand side, going out from the supply chain, to the market. The indexes are indicating the size of the impact on business value in the next link.

Still another disturbance type is disturbances *into the supply chain*, i.e. from natural resources into the supply side of the supply chain, caused by difficulties in getting access to the needed natural resources. The index is marked NS and is indicating the size of the impact on business value in the next link.

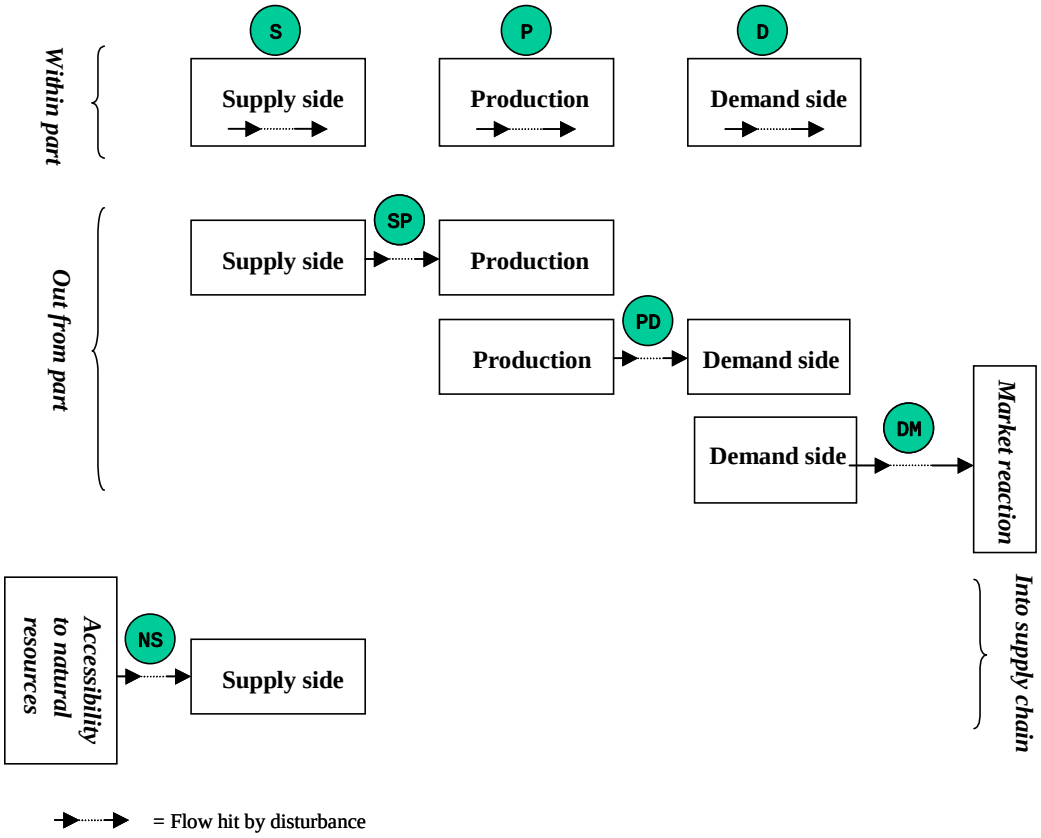

Figure 2.2 Individual supply chain risk indexes for the three disturbances

2.2.2. Disturbance multiplication

Disturbances that pass through a part of the supply chain, e.g. production, can be diminished, enlarged or unaffected during their passage. The indexes are marked with MuS, MuP and MuD. The indexes are indicating the multiplication effect on BVI.

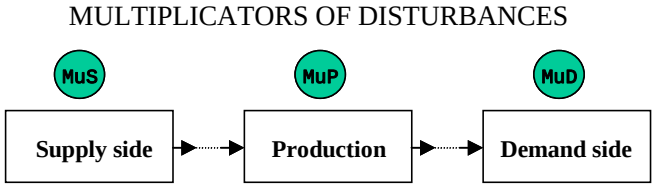

Figure 2.3 Indexes for multiplication of disturbances

2.2.3. Market reaction

The interesting aspect of the market is here its reaction on disturbances in the physical flow. Disturbances that reach the market affect both revenues and costs. Market reaction was in the general conceptual model split into market confidence and market patience. *Market patience* reflects the short-run reaction of the market on delivery problems. Index is here Mp. *Market confidence* reflects the long-run reaction of the market on delivery problems. The index is here Mc. The indexes are indicating the multiplication effect on BVI.

Indexing is now finished and it is time to sum up.

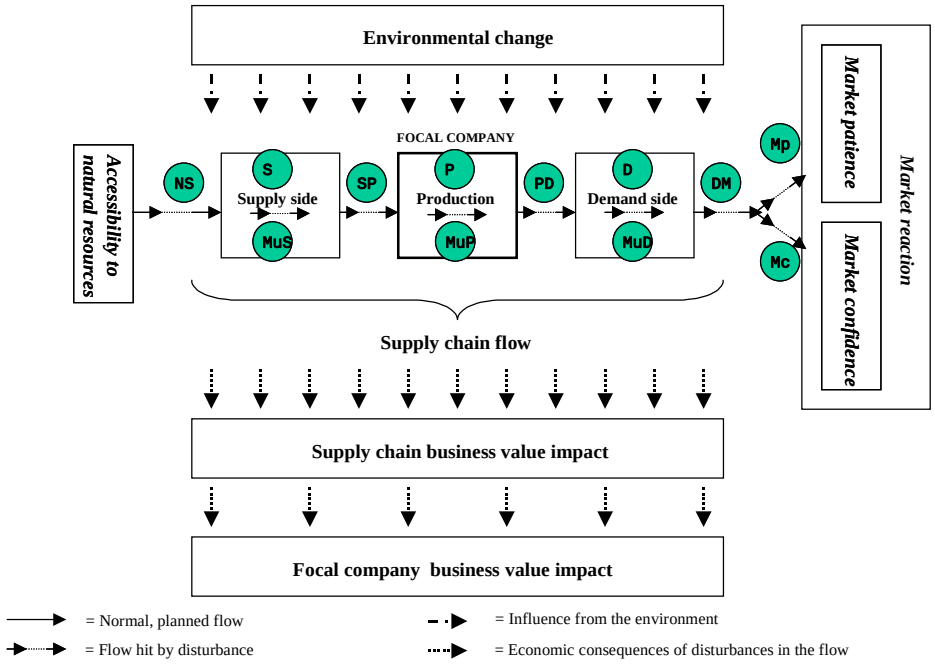

Figure 2.4 The adapted general model with indexes positioned

2.2.4. Index ranges

For each index the level of risk is indicated by a figure between 0 (zero) and n. Zero has a somewhat different meaning for the different indexes. For the three disturbance types (within part, out from part, and into the supply chain) zero means no risk at all. For disturbance multiplication zero means that all disturbances are taken care of within that supply chain part and none is passed on (A figure higher than zero but below 1 indicates that disturbances will diminish through their passage, 1 indicates that the disturbances are unaffected by the passage and higher than 1 that disturbances are enlarged through their passage). For market patience zero means that no sale is lost in the short run – the customers are prepared to wait for delivery. For market confidence zero means that no sale is lost in the long run – the customers will have unaffected confidence.

Table 2.1 The indexes and their ranges

Index regarding	Where in the flow?	Marking	Index value range	Indicating
Within part	Supply side	S	0 – n	BVI-impact
-"-	Production	P	0 – n	-"-
-"-	Demand side	D	0 – n	-"-
Out of part	From Supply side to Production	SP	0 – n	-"-
-"-	From Production to Demand side	PD	0 – n	-"-
-"-	From Demand side to Market	DM	0 – n	-"-

Into the supply chain	From Nature to Supply side	NS	0 – n	-"-
Disturbance multiplication	Supply side	MuS	0 – n	Multiplication effect
-"-	Production	MuP	0 – n	-"-
-"-	Demand side	MuD	0 – n	-"-
Market reaction	Market patience	Mp	0 – n	-"-
-"-	Market confidence	Mc	0 – n	-"-

2.3. Calculating principles

Through the calculation principles we are trying to construct indexes of higher order that reflect the potential negative business value impact (BVI). Calculation is divided into one part taking care of the disturbances that do not reach the market and another part for those who do. Another principle is to start with the limited disturbances and then enlarge the scope.

A: Calculate the BVI-index for disturbances that stay within the supply chain (do not reach the market)

- **A1:** *Disturbances started and handled within one part of the supply chain:* S + P + D.
- **A2:** *Disturbances beginning within one part and going out of that part but not reaching the market:* SP + PD + SP*MuP.
- **A3:** *Disturbances into the supply chain and possibly further on within the supply chain but not reaching the market:* NS + NS*MuS + NS*MuS*MuP.
- **A4:** *Summarize A1 to A3:* A1 + A2 + A3.

B: Calculate the disturbances that reach the market

- **B1:** *Disturbances that have their origin within the supply chain and going out of the supply chain on to the market:* DM + PD*MuD + SP*MuP*MuD.
- **B2:** *Disturbances from nature into the supply chain, trough the supply chain and out of the supply chain on to the market:* NS*MuS*MuP*MuD.
- **B3:** *Summarize B1 and B2:* B1 + B2.

C: Calculate the BVI-index for disturbances that reach the market

- **C1:** *Consider the short-term reaction of the market by multiplication of the sum from B3 with the index for market patience:* Mp*B3.
- **C2:** *Consider the long-term reaction of the market by multiplication of the sum from B3 with the index for market confidence:* Mc*B3.
- **C3:** *Summarize C1 and C2:* C1 + C2.

D: Calculate the BVI-index for all disturbances = Total BVI-index

- Summarize A4 and C3: A4 + C3.

Table 2.2 Calculation scheme

Case XXXX

	FORMULA	CALCULATION	TOTAL
A: BVI-index for disturbances that stay within the supply chain			
A1. Disturbances within one part of the supply chain	S + P + D		
A2: Disturbances from one part to another part in the supply chain	SP + PD + SP*MuP		
A3: Disturbances into the supply chain and possibly further on within the supply chain	NS + NS*MuS + NS*MuS*MuP		
A4: Summarize A1 to A3	A1 + A2 + A3		**0**
B: Disturbances that reach the market			
B1: Disturbances from within the supply chain out on to the market	DM + PD*MuD + SP*MuP*MuD		
B2: Disturbances into the supply chain, through it and out on to market	NS*MuS*MuP*MuD		
B3: Summarize B1 and B2	B1 + B2		*0*
C: BVI-index for disturbances that reach the market			
C1: Market patience	Mp*B3		
C2: Market confidence	Mc*B3		
C3: Summarize C1 and C2	C1 + C2		**0**
D: Total supply chain/focal company risk index			
D1: Summarize A4 and C3	A4 + C3		**0**

A disturbance can either be reaching the market, not reaching the market or both. In the first case the impact on business value is considered under C, in the second case it is considered under A. In the mixed case where some of the disturbance is taken care of within the supply chain and some is reaching the market the business impact is considered both under A (that part not reaching the market) and C (that part that does reach the market).

Indexing and calculations can be done either:

- for that supply chain which is defined by the focal company and the focal product; Total supply chain BVI-index = Total supply chain risk index, or;
- for the focal company with a supply chain perspective; Focal company BVI-index = Focal company (with a supply chain-perspective) risk index.

In the latter case not all indexes are of relevance or full relevance simply because the total supply chain business value impact is spread between many companies in the chain. The focal company does not have to bear it all itself. This is indicated in the model (figure 2.4) through fewer arrows to focal company BVI than to supply chain BVI. Which of the supply chain BVI-indexes that also are of relevance to the focal company has to be decided from situation to situation and is dependent on factors like the existence of risk-sharing agreements and possible ownerships outside production e.g. in local marketing units.

3. Three illustrating cases

The three cases presented below are illustrating the possible use of the model but have no ambition to seriously reflect the actual supply chain risks in the cases. Each case starts with a short general introduction of the companies and then follows, with the physical flow as a base, descriptions of the different supply chain elements and risks and indexes are set based on those descriptions. The sequencing of the descriptions is following the direction of the physical flow starting with natural resources and going forward. Indexing is done from the perspective of the total supply chain. All indexes are set between 0 and 5 where zero indicates no risk at all, 1 small risk and 5 very high risk. After indexing is finished all the indexes are summed up in a table and the total supply chain risk index calculated.

3.1. The Alfa case with indexes

Alfa is a big company operating on the European market within the chemical-technical trade. It has a number of production units all over the continent. Input to the product is mainly different types of basic chemicals, the product and the production process is relatively simple. The rate of change in the trade is moderate. Alfa is engaged in the production and to some extent also in the distribution and selling of the product. The market consists of both industrial buyers and private households. Here only that part of the company serving private households (the consumer market) is considered.

The *natural resources* necessary for producing the needed basic chemicals are practically unlimited and spread on many locations but access can change somewhat. Events like for instance flooding or strikes can make it necessary to change location and this could cause increased costs. (NS-index[1] = 1).

On the *supply side* single sourcing is frequently used but there tend to be several potential parallel suppliers. Each supplier is also carrying buffer stocks. A disturbance in the input of natural resources is therefore likely to be handled within the supply side and not passed on (MuS-index = 0.3). Some of the produced chemicals are flammable and there is a constant risk for fire in the factories of those suppliers. But since there probably are several other suppliers of the same chemical the disturbance can be handled within the supply side. Costs will however become higher (S-index = 3). The risk that a disturbance will spread to production is limited (SP-index = 1). But Alfa does not have to consider those supply risks at all on a daily basis since Alfa has deals with their suppliers based on VMI and full economic compensation for shortages. So if there should be a shortage of some chemical Alfa will be compensated by the supplier for all the negative consequences that this shortage might have on Alfa.

Production means mixing different chemicals according to a certain prescription, tapping the mixture into cans and labelling them. The products are standard products where the same product is bought by a number of different customers. The same or similar type of product is produced at several sites and normally in 1-shift. No unique, advanced machineries or specially designed premises are needed. Some buffer stocks also exist. A disturbance into production is therefore likely to at least partly be handled within production and not passed on (MuP-index = 0.5). Some of the chemicals used in production are highly flammable and have to be treated with great care. A fire starting in one part of a production unit can also easily spread to other parts of the unit. Fire is a real danger and some production units have their

[1] Indexes are set from a total supply chain perspective.

own fire brigade. A fire will, although insurances exist, cause economic losses (P-index = 4). The existence of several parallel sites within Alfa with overcapacity in production makes it possible in case of fire in one production unit for other production units to take over the production (PD-index = 1).

On the *demand side* a certain storing of products exists. The different final products can be used separately but are in practice partly dependent on each other (MuD-index = 0,7). Risks exist linked to the transportation and storing of the final products but they are limited since each transport unit has limited size and storing is spread on many premises (D-index = 2). Because of storing on many places of the same product deliveries between different units on the demand side will take care of most incidents and the disturbance will not reach the market (DM-index = 1).

Risks linked to *market patience* are neither high nor low. Delivery problems would certainly mean lost sale for the period with delivery problems, but since it is easy for a customer to change back as well, sale might rapidly go back to normal again as soon as the delivery problem is solved (Mp-index = 3). Risks linked to *market confidence* are, because of the ease of the customer to switch over to another supplier and to switch back again, low. But there is always the risk that the customer liked the product of the competitor better than Alfa's. Delivery problems in one period are therefore likely to have impact on sale in the following periods (Mc-index = 2).

Table 3.1 Indexes for case Alfa

Where in the flow?	Index regarding	Marking	Set index range	Set index
From Nature to Supply	Into the supply chain	NS	0 – 5	1
Supply side	Disturbance multiplication	MuS	0 – 5	0,3
Supply side	Within parts	S	0 – 5	3
From Supply side to Production	Out of parts	SP	0 – 5	1
Production	Disturbance multiplication	MuP	0 – 5	0,5
Production	Within parts	P	0 – 5	4
From Production to Demand side	Out of parts	PD	0 – 5	1
Demand side	Disturbance multiplication	MuD	0 – 5	0.7
Demand side	Within parts	D	0 – 5	2
From Demand side to Market	Out of parts	DM	0 – 5	1
Market patience	Market short-term reaction	Mp	0 – 5	3
Market confidence	Market long-term reaction	Mc	0 – 5	2

Using the indexes on the calculation scheme gives us the following:

Table 3.2 Calculations for case Alfa

Case Alfa

	FORMULA	CALCULATION	TOTAL
A: BVI-index for disturbances that stay within the supply chain			
A1. Disturbances within one part of the supply chain	S + P + D	3+4+2	9
A2: Disturbances from one part to another part in the supply chain	SP + PD + SP*MuP	1+1+2*0,5	3
A3: Disturbances into the supply chain and possibly further on within the supply chain	NS + NS*MuS + NS*MuS*MuP	1+1*0,3+1*0,3*0,5	1,45
A4: Summarize A1 to A3	A1 + A2 + A3		**13,45**
B: Disturbances that reach the market			
B1: Disturbances from within the supply chain out on to the market	DM + PD*MuD + SP*MuP*MuD	1+1*0,7+1*0,5*0,7	2,05
B2: Disturbances into the supply chain, through it and out on to market	NS*MuS*MuP*MuD	1*0,3*0,5*0,7	0,105
B3: Summarize B1 and B2	B1 + B2		*2,155*
C: BVI-index for disturbances that reach the market			
C1: Market patience	Mp*B3	3*2,155	6,465
C2: Market confidence	Mc*B3	2*2,155	4,31
C3: Summarize C1 and C2	C1 + C2		**10,775**
D: Total supply chain risk index			
D1: Summarize A4 and C3	A4 + C3		**24,225**

Summing-up the discussion we can conclude that risks linked to the supply side and to the accessibility of natural resources are low. Risks linked to demand side and to market reaction are also low. Risks linked to disturbances within a single production unit are however very high. But those disturbances do not have to reach the end customer because there are other production units within the company with the same or similar products and production equipment that could easily take over the production. By adding overtime or more shifts production capacity could rapidly be raised. Production costs will become higher but customers will get their products on time and consequently will revenues not be affected. The calculations (table 2.4) showed that the BVI-index for disturbances that stay within the supply chain are somewhat higher than the BVI-index for disturbances that reach the market. The former are related to increased costs and the latter mainly to lost revenues. The potential of losing revenues is thus in case Alfa less important then that of getting increased costs. We can also conclude that the *total risk* related to disturbances in the supply chain is moderate.

3.2. The Beta case with indexes

Beta is a big international company operating on a world market with advanced IT-based products for industrial use. The rate of change in the trade is high. A number of different products are produced but one is economically dominating and that product, here called

product x, will be focused. Input to product x is a number of very advanced components, some of which are produced in different supply units within the company (group companies) itself and some of which are bought from outside. Several parallel production units exist but most of the production of product x takes place in one of the production sites. Beta takes care of all the selling of the product and partly also its distribution.

The *natural resources* necessary for producing the components are practically unlimited. They are also geographically spread on many locations. Access can however sometimes be a problem, but only a minor problem (NS-index = 0,4).

At the *supply side* we can conclude that some of the needed components are standard components and will not be discussed here any further but most of them are specially developed components for product x. Several of those unique components are single sourced and this constitutes a clear risk. Some buffer stocks exist however and they will take care of most possible disturbances in the input of natural resources (MuS-index = 0.6). Sensible, highly specialised equipment is used and if there is a break-down it will take considerable time to get back to normal volume again (S-index = 4). Since the components are unique and single sourced there exist no parallel suppliers (SP-index = 4).

Certain buffer stocks of components exist in the *production* units but no stocks of ready-made products since all copies of product x are produced according to customer order specification and are more or less unique (MuP-index = 0.5). The production process can be divided into assembly, downloading of software and testing. Assembly is using standard equipment but the other two production steps need access to unique, advanced equipment. This is a clear risk especially as such a great deal of the total production is concentrated to one of the production sites. On the other hand there is no handling of dangerous materials that could cause fire or in other ways destroy the unique equipment (P-index = 2). The absence of a buffer stock of ready-made products in combination with the concentration of the production to mainly one production unit constitutes a clear risk of disturbances out from production to demand side (PD-index = 3,5).

No buffer stocks exist on the *demand side* because you cannot have a buffer of final products in a situation where each copy of the product is tailor-made. Certain product assortment links exist meaning that the effects of a disturbance passing through will be increased since other products will be affected as well (MuD-index = 2,5). Some risks also exist during the physical distribution of the product but they are minor since each transport unit, like a lorry, only is carrying a limited number of the product (D-index = 1,5). Since the products are customized it can take some time to replace a lost unit of the product with some delay in deliverance to the end customer as a result (DM-index = 2).

Market patience related risks are probably moderate to low. There are several other suppliers of product x on the market but it is not so easy for a customer to quickly change over to another supplier (or to change back) so the customer is in the short run locked up to a certain supplier (Mp-index = 1). *Market confidence* related risks are probably very high. Since a customer is locked-up to its supplier and since product x is a quite expensive product it is very important for the customer to have confidence in the ability of the supplier to deliver. If this is not the case the customer will probably not dare to choose the supplier next time there is a big strategic investment (Mc-index = 5).

Summing-up the discussion we can conclude that Beta is exposed to several serious risks. One risk is caused by unique, single sourced components, another by the concentration of production to mainly just one unit in combination with the need of unique advanced

production equipment, and a third one to the fact that there exist product assortment links but no buffer stocks of final products. Finally market confidence is critical because it is very likely that there will be a considerable negative market reaction on delivery problems. If we put the indexes in the calculation scheme presented in table 2.2 we will get a BVI-index for disturbances that stay within the supply chain of about 18, a BVI-index for disturbances that reach the market of about 96 and a total supply chain risk index of about 114. The *total risk* related to disturbances in the supply chain is thus very high especially because of the high risk of losing revenues because of disturbances hitting the market.

3.3. The Gamma case with indexes

Gamma is a medium-sized company producing high-priced electronic consumer products of good quality with an advanced design. The market consists of a number of countries above all in Europe. Input is different electronic components of good quality and design-related components. Production consists of assembly and testing. The electronic components in the product have a high rate of change while design is changing much slower. Trade rate of change can therefore be said to be moderate. Gamma is engaged both in designing, producing and marketing their products.

The *natural resources* necessary for producing the components can be regarded as unlimited and always accessible (NS = 0).

On the *supply side* we can note that for production of the electronic components advanced machinery is needed that might be sensible to dust etc. (S-index = 3). All the electronic components are however standard components and alternative suppliers can be found. Besides Gamma is a small buyer of electronic components. Gamma only needs small quantities and is prepared to pay well for those components so they are pretty sure to get them as long as there are any on the market to buy. The components related to the design are unique but not that difficult to produce and alternative suppliers can be found. But both situations might lead to increased costs (SP-index = 1).

Production is concentrated to just one big production site working in 1-shift and usually having spare capacity. There is thus a considerable overcapacity in production and minor delays in input could easily be handled. There are also buffer stocks of components (MuP-index = 0,2). In the production process mainly standard equipment for assembly and testing is used. If the factory would be totally destroyed production could be started up in another site after a few weeks (P-index = 2). But the fact that there exists only one factory and that most products are built to customer order and consequently there are no buffer stocks of ready-made products creates risks for disturbances created within production to be passed on to the demand side (PD-index = 3).

On the *demand side* we can notice that the products are sold through special shops that only sell Gamma products and have exclusive selling rights within a local area. The different products are sold more or less independently of each other. Limited buffer stocks exist. The products are normally customized but in some cases the customer might accept another equal or better product (MuD-index = 0,8). There are certain risk that the products will get destroyed or lost during distribution but those risks are limited (D-index = 1). But if there is a disturbance within the demand side then it is likely that it will hit the market since most products are customized and consequently we can not have buffer stocks (DM-index = 1).

The consumer probably already back home has a product which gives the same basic function as the one he has ordered and is therefore more willing to accept delays. The ordered product is furthermore produced according to customer specifications which makes the customer less

sensible to delays in deliverance. *Market patience* is therefore quite high and the risks low (Mp-index = 0,5). Repeated delivery problems would probably have some negative effects on *market confidenc*e but generally the disturbance-related risks are also here quite low (Mc-index = 0,6).

Summing-up the discussion we can conclude that risks in production is limited and so are risks related to other parts of the supply chain. If we put the indexes in the calculation scheme presented in table 2.2 we will get a BVI-index for disturbances that stay within the supply chain of about 10, a BVI-index for disturbances that reach the market of about 4 and a total supply chain risk index of about 14. The *total risk* related to disturbances in the supply chain is obviously low. Especially noticeable is the extremely low risk of losing revenues because of disturbances hitting the market.

3.4. Commenting on the cases

The cases have illustrated that *the risk situation is very different* in different supply chains both when it comes to the total risk in the supply chain and to the risks related to different parts of the model. Perhaps the most striking is the difference in importance in the three cases between on one hand risks related to disturbances that stay within the supply chain and on the other hand risks related to disturbances that hit the market.

The risks considered and calculated in the three cases were the total supply chain flow risks and not the focal company risks. The *difference between focal company risks and total supply chain risks* can be illustrated by case Alfa. Alfa had deals with their suppliers based on VMI and full economic compensation for shortages. That means that Alfa in their focal company risk index does not have to include the risk of disturbances in supply, because if there is a shortage Alfa will be compensated by the supplier for all the negative consequences that this shortage might have on Alfa. Differences can thus be created through actions like contracting but generally the bigger part the focal company has of the total value adding in the supply chain the smaller the difference will be between focal company risks and total supply chain risks.

Finally it might be noticed that Gamma is exposed to quite big risks but they are not related to the supply chain flow but to design. Advanced, bold design is the prime competitive advantage of the company and every introduction of a new product assortment based on a new design idea is critical because Gamma could never be sure of market reaction. This illustrates the general fact that *considerable risks exist outside the supply chain* flow.

4. Some final comments

In this paper a supply chain risk valuation model has been developed with the help of which risks related to disturbances in the physical flow in a supply chain can be valuated through indexing. The model helps putting values on supply chain risks in a systematic way.

An interesting aspect of the model is that if we can find out how different risk management actions affect different risk indexes then we can calculate how the total risk in the supply chain is affected. The model can be used as a "tool" to start discussions around supply chain risk issues in companies. The model can also hopefully become a base for a more efficient supply chain risk management work.

Using indexes can be a way to quickly and with limited resources get a broad grip of the total risks – not least in new risk situations. The alternative is often not to have any figure at all for

the supply chain risks. But we have to be careful because indexes create a new risk themselves – the risk that we believe too much in them.

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